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Spray Pyrolytically Deposited CdSe Thin Films For Photoelectrochemical Solar Cells

Science

KEYWORDS : Spray pyrolysis, photo-electro-chemical cell, photo-anode, polysulfide solution

Dr. Yashwantrao. D. Tembhurkar — Department of Physics, S. K. Porwal College Kamptee, Nagpur-441002

Mr. Anil S. Meshram — Department of Physics, S. K. Porwal College Kamptee, Nagpur-441002

ABSTRACT

A thin film of CdSe is a semiconducting material for the use in the fabrication of hetero-junction solar cell. Spray pyrolysis is a simple, cheap and inexpensive method of depositing thin films of large area. We have deposited thin films of CdSe on glass substrate at 3250C by this method, using aqueous solutions of cadmium chloride and Selenium dioxide. We report the characteristics of CdSe/polysulfide electrochemical solar cell having photo anode prepared by spray pyrolysis in the form of thin films. The conductivity of films was measured using four-probe method. The current-voltage characteristics of the resulting CdSe/polysulfide solution/ pt PEC cells were measured.

Introduction

A large number of researchers have concentrated on the field of solar energy; there is need of more attention as a solar energy is one of the promising energy sources for the future. The conversion of solar energy to electrical energy has been demonstrated by means of photo electrochemical (PEC) cells with CdSe [1, 2] and n-$CuInSe_2$, n-$CuInS_2$ polysulfide electrochemical solar cells [3, 4]. The performance of CdSe semiconductor electrodes can often be greatly improved by limited acid etching. There is an inverse correlation between the presence of surface states within the forbidden gap of the semiconductor and the efficiency of PEC cells. Heller et al [5] suggested that acid etching of a single crystal of CdSe removes the surface states which act as a barrier traps and recombination centers.

A more easily controlled activation method, particularly suitable for thin film II-VI semiconductor electrodes is a photo-activation process developed in work on PEC cells. In this process, the thin film of CdSe electrodes was immersed together with platinum as a counter-electrode in a salt solution (eg. Nacl and illuminated under closed circuit condition. When the photo activated CdSe thin films electrodes was subsequently used as the photodiode in a photo electrochemical cell with polysulfide solution, both the photocurrent and the fill factor were enhanced.

In the present work, we report the characteristics of CdSe/polysulfide electrochemical solar cell having photo anode prepared by spray pyrolysis in the form of thin films.

Preparation of Photo-anode

A CdSe thin film was deposited on SnO_2 deposited glass substrate so as to cover half the area. Aqueous solutions of 0.02 M of cadmium chloride and selenium dioxide were mixed in 1:1 proportion by volume for spraying. The temperature of the substrate was maintained at 325^0C and was measured by a pre-calibrated copper-constantan thermocouple. The solution was sprayed at a pressure 12 kg/cm^2. The rate of flow was maintained at 3.5 ml/min. the conductivity of the film as tested by hot-probe method and was of n-type. The conductivity of films was measured using four-probe method [6] and was found to be of the order of 6- 8 $\Omega^{-1}cm^{-1}$. To get a contact lead, copper wire was placed on the SnO_2 and indium metal was diffused by hot soldering rod on the copper wire and SnO_2. Thus ohmic contact on the SnO_2 layer works as back contact for CdSe films. Epoxy was used to seal the copper wire contact and all portions of SnO_2 layer on which the film was not deposited and to insulate all bur exposed face of the film. The electrode prepared was used as photo-anode. The thickness of the photo-anode was of the order of 1-2 µm.

Study of Photoresponse

Photoresponse was conducted by immersing the CdSe electrode with platinised platinum counter electrode in a weakly acidic salt solution and illuminated the CdSe electrode under closed circuit condition for a few minutes with a projector light. The CdSe electrode was subsequently rinsed water and dried. In a few cases, the CdSe electrode and platinum electrode were immersed in a separate cell compartment connected a salt bridge so that the pH of each cell compartment could be varied.

The current-voltage characteristics of the resulting CdSe/polysulfide solution/ pt PEC cells were measured. In order to select the proper light intensity, variation of photoresponse with light intensity was studied for illumination of photo-anode. The composition of the polysulfide solution was mixed 1 M NaOH, 1 M Na_2S, 1M S. The electrode was stable in these electrolyte solutions. Short circuit current (Isc) and open circuit voltage (Voc) were measured as a function of light intensity. Potential difference of photo-anode was between photo-anode and saturated calomel electrode (SCE). The Voc is obtained by subtracting 0.244V (potential of SCE) from the voltage measured between photo-anode and calomel electrode. The platinum electrode was plotted fig. 1 (a, b)

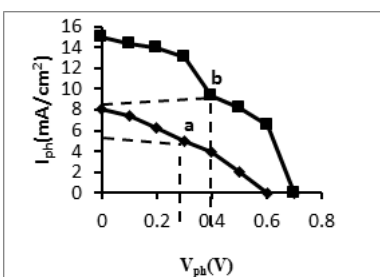

Fig.1. Output characteristic of n-CdSe in a solution 1M NaOH, 1M Na_2S, 1M S at room temperature a) as deposited b) etched

It is observed that open circuit voltage and short circuit current increase with light intensity and approach saturation value beyond 70 mW/cm^2 light intensity. This behavior is similar to the case of p-n or sc/metal junction in solid-state photo-anode [7].

I-V Characteristics

A PEC cell is characterized by its current-voltage output with load resistance. For the purpose, after 2-3 minutes of illumination of constant light intensity, the corresponding value of photocurrent (Iph) and photo voltage (Vph) are recorded under variable load resistance to obtain the values of conversion efficiency [8-9].

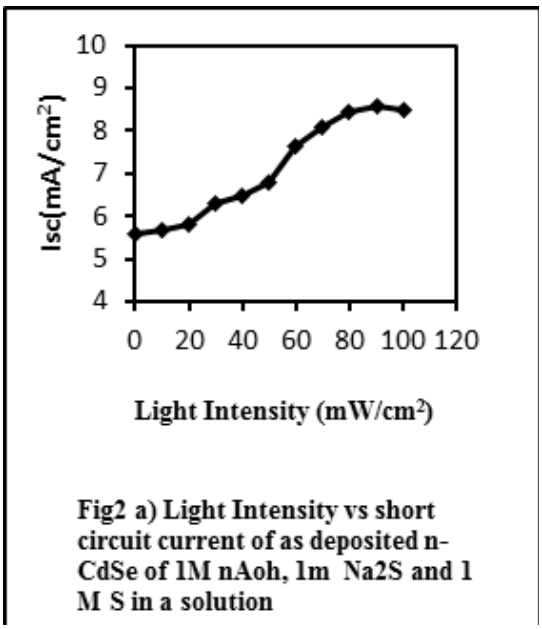

Fig2 a) Light Intensity vs short circuit current of as deposited n-CdSe of 1M nAoh, 1m Na2S and 1 M S in a solution

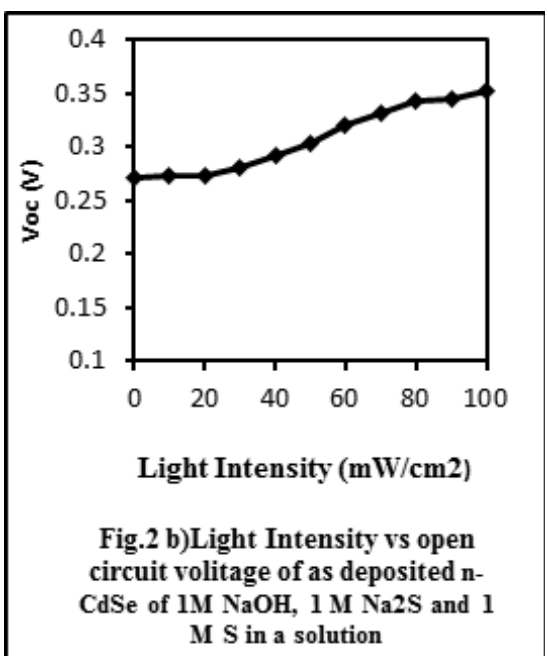

Fig.2 b)Light Intensity vs open circuit volitage of as deposited n-CdSe of 1M NaOH, 1 M Na2S and 1 M S in a solution

Fig. 2 a) shows the I-V characteristic for constant light intensity at 70 mW/cm² of as deposited CdSe photo-anode. The special importance in obtaining good photoactive electrode as their surface preparation. For this the film of CdSe was etched in 5:1 (HCl: HNO_3) for 30 second and rinsed quickly in distilled water. This process was repeated 2-3 times.

The fill factor (ff) can be calculated using the relation,

$$ff = \frac{I_m}{V_{oc}} \frac{V_m}{I_{sc}}$$

Where Vm and Im can be calculated by computing the product at various points along the curve and selecting the point when the product is maximum.

The optical to electrical energy conversion efficiency in a semiconductor/liquid junction solar cell given by,

$$\eta = \frac{V_{OC}\, I_{SC}}{P_{in}} \times 100$$

where Pin is the light (optical power) input. From the fig. 2 a) & b), the fill factor and efficiency were calculated using the above relation of and these results are listed in table.1. The similar result was published [3, 4] for $CuInSe_2$ and $CuInS_2$ photo anode.

Thin Film n-CdSe	Fill Factor (ff)	Efficiency (η)
a) as deposited	0.315	2.16
b) etched	0.373	5.595

Result and discussion

It was observed that the short circuit current open circuit voltage, fill factor overall power conversion efficiency increase after etching the photo anode. The CdSe surface turned from dark gray to blue as a result of photo activation. But the blue color disappeared after the electrode was immersed in polysulfide solution and the surface become darker and less reflective. Chin-hoin et al reported the value of fill factor was between 0.27 to 0.40. Our calculated value of fill factor was 0.373 which is greater than this due to the polycrystalline thin film and which shows the improvement in energy conversation efficiency.

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REFERENCE

[1] Ravi, R., Purkayastha, Kalita, P K., Sarma, R., Das, H L and Sarma, R K., July (2005), "Photo electric properties of CdS thin film prepared by chemical bath deposition", Indian J. Pure & Appl. Phys.,45 624-627. | [2] Pandey. P K., Bhave, N S., and Kharat, R B., Jan (2006) "Structural, optical, electrical and photovoltaic electrochemical studies of cobalt molybdate thin films". Indian J. Pure & Appl. Phys., 44 52-58. | [3] Tembhurkar, Y D and Hirde, J P., Oct (1994) "Spray pyrolytically deposited n-CuInSe2/ polysulfide photoelectrochemical solar cells". Bull. Mater. Sci., 17 (5), 465-468. | [4] Tembhurkar, Y D., Oct (1997), "n-CuInS2/polysulfide photoelectrochemical solar cells prepared by spray pyrolysis."Bull. Mater. Sci., 20 (7) 1011-1014. | [5] Heller, A., Chang, K C., and Miller, B., (1977), "Spectral Response and efficiency Relation in semiconductor liquid junction solar cells", J. Electrochemi.soc., 124 657. | [6] Valde, L B., (1954), "Resistivity measurement on Germanium for Transistor", Proc IRE, 42, 420. | [7] Aruchamy, A., Aravamundari, G and Rao, G V., (1982), "Semiconductor based photoelectrochemical cells for solar energy conversion-An overview", Bull. Mater. Sci., 4 (5) 483. | [8) Chin-hoin, Liu. Judith Olsen, Sounders, David, R., and Wang, Jui H., Jan (1981), "Photoactivation of CdSe films for photoelectrochemical cells" J. Electrochemi. Soc. Electrochem. Sci. and technology, 1224-1228. | [9] Butler, M A., Ginley., (1980) "Principal of photoelectrochemical, solar energy conversion", J Mater. Sci.15 1-19. | 10] Cahen, David., Hodes, Gary and Manssen, Joost., (1978), "S/Se substitution in polycrystalline CdSe photoelectrodes" (photoelectrochemical Energy Conversion), J Electrochemi. Soc. 125 1628. | 11] Wagner, Sigurd and Shay, J L., (1977), "n-CdS/n-GaAs voltage-enhanced photoanode", Appl. Phys. Lett., 31(7) 446-447. |